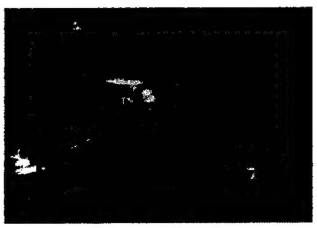
OIL RESPONSE IN FAST WATER CURRENTS: A DECISION TOOL



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16. Abstract (MAXIMUM 200 WORDS)
This decision tool is a companion manual for the report, "Oil Response in Fast Currents, A Field Guide" (Report CG-D-01-02). This booklet provides tables, pictures and figures, mostly from out of the guide, that can be used to make decisions in the field or command post. Users should refer to the guide for additional details concerning decision methods, techniques and equipment.

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OVERVIEW OF THE OIL SPILL RESPONSE: FAST WATER DECISION TOOL

Purpose

This document provides oil spill response personnel with a job aid for organizing and implementing oil spill containment and cleanup measures in a fast water environment. Fast water refers to any situation where river, harbor or estuary surface current velocities are expected to exceed one knot. Experience and research have shown that special strategies and tactics are warranted in channeling, containing and recovering spilled oil, and safety should be a main concern.

This decision tool is a companion document to the more comprehensive report, "Oil Spill Response in Fast Currents, a Field Guide," published by the Coast Guard R&D Center in 2002, which is available from the National Technical Information Service in Springfield, VA. This decision tool assumes that the user will have read and understood the material contained in the parent Field Guide. This tool has been limited to essential graphics and tables to refresh the responder's memory, allow him/her to quickly assess the situation and formulate an action plan, and communicate this plan to other personnel.

Organization

The decision tool is organized to provide information for developing fast water response strategies. This process is depicted in the decision flow diagram in Figure 1. For each step in the process, the necessary input information and options are specified. Tables and figures provide the primary options open to the responder, and graphically depict various boom and skimmer tactics for oil exclusion, diversion and recovery. In addition, a set of easy to use graphics and tables is provided to allow the responder to compute key deployment parameters such as boom length, deflection angles, mooring line tension and the number of anchors required.

Relation to Other Spill Response Documents and Resources

In addition to familiarity with the Field Guide, responders should be familiar with the basic National Interagency Incident Management System/Incident Command System (NIIMS/ICS) spill response doctrine as outlined in the USCG Incident Management Handbook. The Area Contingency Plan should also be available and consulted for information on sensitive resource locations and environmental data such as anticipated current velocities, oil behavior and natural collection points. The responder should also consult with the NOAA Scientific Support Coordinator (SSC), local First Responders, as well as harbormasters and local mariners to gather information to verify the viability of the strategy and tactics arrived at using this decision tool.

Figure 1. Fast water response decision chart.

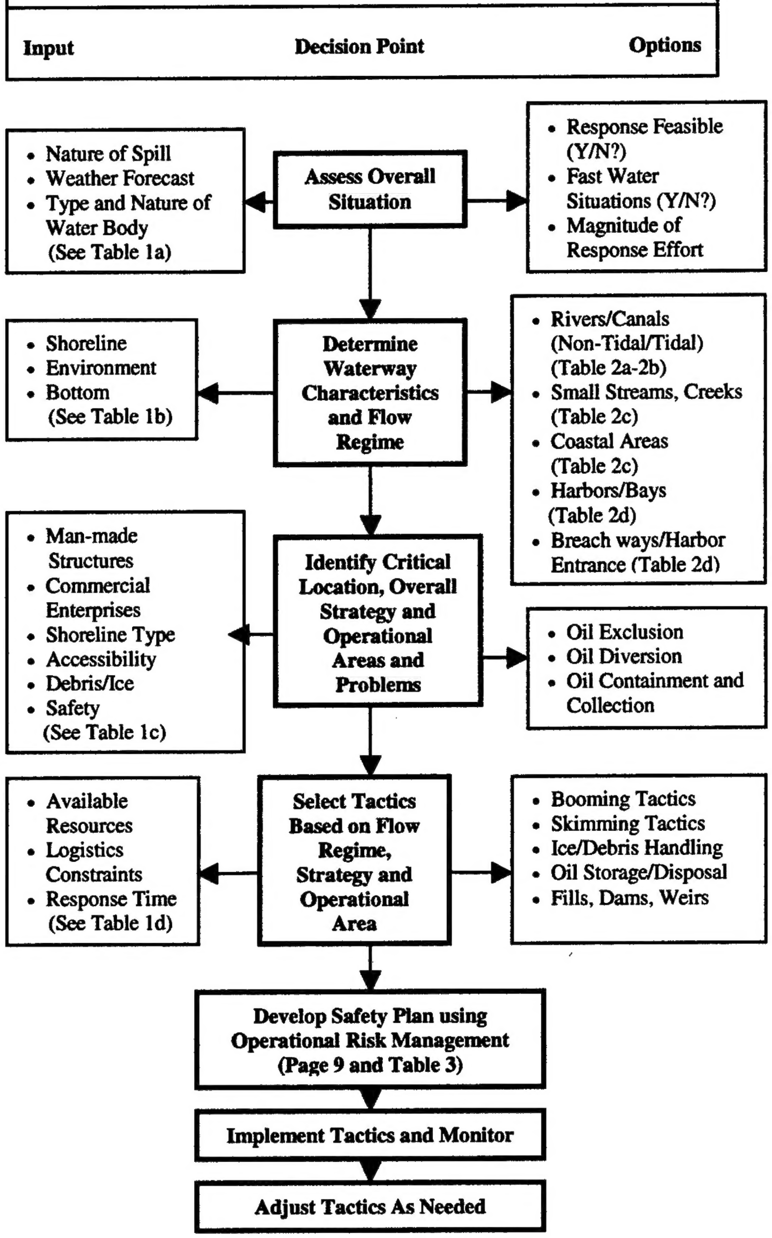


Table 1a. Assess overall situation.

Selection Factor	Related Sub-Factors	Info Sources
Nature of the spill	• Amount and type of oil • Time and place of oil impact (ETA) • Weathering/emulsion issues • History of spills	• PolReps • Area Contingency Plan • NOAA SSC
Weather forecast	• Wind affects oil drift and sea state • Rain affects currents in rivers and coastal areas • Temperature, oil evaporation rate and people endurance • Visibility	• On-Scene Observations • Local forecasts • Marine forecasts • NOAA SSC
Type and Nature of Water body	• River, lake, swamp, inlet, bay, ocean, etc. • Presence of debris or ice • Navigable or not, traffic type & density	• NOAA Charts • Local Responders

Table 1b. Determine waterway characteristics and flow regime.

Selection Factor	Related Sub-Factors	Info Sources
Shoreline	• River (winding, width, etc.), estuary, strait, headland, harbor, inlet, island, etc. • Natural collection points • Sensitive areas	• Area Contingency Plan • NOAA Charts/ ESI Maps
Environment	• Current speed and direction • Tidal action: height, cycle time, reversing currents, slack water, etc. • Waves: height, wave direction, period, breaking or non-breaking, etc.	• On-Scene Observations • Real-time Measurements • NOAA SSC
Bottom	• Water depth and contours • Bottom type (relating to habitat damage and anchoring potential)	• NOAA Hydro Charts • ESI Maps

Table 1c. Identify critical location, strategy, and operational areas and problems.

Selection Factor	Related Sub-Factors	Info Sources
Man-made structures and commercial enterprises	• Piers, breakwaters, bulkheads, bridges, etc. • Water intakes (drinking water, desalination, etc.) • Floating houses, casinos, commercial and recreational traffic • Commercial logs, fish hatcheries, etc. • High volume water traffic	• NOAA Hydro Charts • Local harbormaster • Port authority • Area Contingency Plan
Shoreline type	• Salt marshes and mangroves, sheltered tidal flats, sheltered rocky coasts, exposed tidal flats and vegetation, gravel beaches, beaches • Other threatened or historical areas	• Area Contingency Plan • NOAA SSC • ESI Maps
Accessibility	• Land accesses (bridges, roads, shoreline grade, shoreline vegetation, etc.) • Water access (boat ramps, marinas, fuel, boat draft, specialty vehicles such as jet boats, air cushion vehicles, airboats, etc. • Air accesses (airports and areas for helicopters) • Approval may be needed	• NOAA Hydro Charts • Local harbormaster • Port authority • Area Contingency Plan
Debris/Ice	• Collection and disposal procedures • Natural Collection Points	• First Responders • Area Cont. Plan
Safety	• Personnel Safety • Site specific issues such as accidental ignition sources	• First Responders • Area Contingency Plan

Table 1d. Select tactics based on flow regime, strategy and operational area.

Selection Factor	Related Sub-Factors	Info Sources
Available resources/ Logistics (Response Time to Plan and Deploy)	• Response organizations: On Scene Coordinator (OSC), Responsible Party (RP), Oil Spill Response Organization (OSRO), etc. • Estimated Time of Deployment (ETD) • Response equipment, locations and availability (effectiveness in the fast-water conditions) • Boats (HP for speed & towing in currents) • Response personnel, their training, location & availability (experience in swift currents) • Logistics support network & equipment • Repair and Maintenance facilities • Communications	• USCG Incident Management Handbook • Area Contingency Plan • Vessel/Facility Response Plan • Local OSRO

Table 2a. Fast current scenarios and tactics in rivers/canal (non-tidal).

Scenario	Amplifying Information	Tactics
Rivers/Canal (Non-Tidal): Depth is greater than typical boom skirt depth. May have tidal influence, but current always goes in same direction	Current speed dependent Vessel traffic dependent	• Single Diversion Boom (Figure 2) • Current < 2 knots use boom skirt of 12 inches • Current > 2 knots use boom skirt 6 inches or less
	Currents > 2 knots	• Cascading Diversion Boom (Figure 4) • Use short skirts, short boom lengths and sufficient overlap
	Collection areas available on both sides	• Chevron Booms (Figures 6-7) • Open for vessel traffic • Closed if no traffic
	Currents < 2 knots and river is wide	• Single Diversion Boom • Exclusion Boom for Sensitive Areas (Figure 5) • Encircle & Divert to Collection Area
	Sufficient room to maneuver	Skimmers for Collection (Figures 10-11)
	Vessels not available	Boom Vane or Flow Diverters (Figure 9)
	Special Conditions	Air and Water Jets
	Isolated Areas	Sorbents and Pom-Poms

Table 2b. Fast current scenarios and tactics in rivers/canals-(tidal).

Scenario	Amplifying Information	Tactics
Depth is greater than typical boom skirt depth Current reverses direction	Current speed dependent Vessel traffic dependent Special methods needed to compensate for tides	• Diversion Boom – need double set (Figure 2) • Current < 2 knots use boom skirt of 12 inches • Current > 2 knots use boom skirt 6 inches or less
	Currents > 2 knots	• Cascade Boom - may need double set (Figure 4) • Use short skirts, short boom lengths and sufficient overlap
	Collection areas available on both sides	• Chevron - may need double set (Figures 6-7) • Open for vessel traffic • Closed if no traffic
	Currents < 2 knots and river is wide	Encircling
	Isolated Areas	Sorbents and Pom-Poms
	Sufficient room to maneuver	Skimmers (Figures 10-11)
	Vessels not available	Boom Vane or Flow Diverters (Figure 9)
	Special Conditions	Air and Water Jets
	Isolated Areas	Sorbents and Pom-Poms

Table 2c. Fast current scenarios and tactics in small streams and coastal areas.

Scenario	Amplifying Information	Tactics
Small streams, creeks, culverts: Depth is less than boom skirt depth	Dependent upon flow rate	▪ Single Diversion for volume flow greater than about 10 cubic feet/second (Figure 2)
	Block for low volume flow	• Sealing • Fill • Dams (Figures 12-13) • Weirs
	Design for volume	▪ Overflow/Underflow dams
	Low Flow	▪ Sorbents and Pom-Poms
Coastal Areas: Near shore wave dependent Includes near shore and straits Various depths Usually tidal		▪ Single Diversion Boom Current < 2 knots use boom skirt of 12 inches if no waves
	Currents > 2 knots	• Cascade Boom (Figure 4) • Use short boom lengths and sufficient overlap
	Currents < 2 knots and river is wide	▪ Encircling
	Sufficient room to maneuver	▪ Skimmers (Figures 10-11)
		▪ VOSS/SORS
	Isolated Areas	▪ Sorbents and Pom Poms

Table 2d. Fast current scenarios and tactics in harbors/bays and harbor entrances.

Scenario	Amplifying Information	Tactics
Harbors/Bays: Near shore wave dependent Depth is usually greater than typical boom skirt depth	Use river techniques in specific areas Current speed dependent Vessel traffic dependent	• Single Diversion Boom (Figure 2) • Current < 2 knots use boom skirt of 12 inches if no waves • Current > 2 knots use boom skirt 6 inches or less if no waves
	Currents > 2 knots	• Cascade Boom (Figure 4) • Use short skirts, short boom lengths and sufficient overlap
	Currents < 2 knots and area is large	▪ Encircling
	Sufficient room to maneuver	▪ Skimmers (Figures 10-11)
	Special Conditions Isolated Areas	▪ Air and Water Jets ▪ Sorbents and Pom-Poms
Breach ways and Harbor Entrances: Various depths, Usually tidal	Current speed, vessel traffic and wave dependent	• Single Diversion Boom (Figure 2) • Current < 2 knots use boom skirt of 12 inches if no waves • Current > 2 knots use boom skirt 6 inches or less if no waves
	Currents > 2 knots	• Cascade Boom (Figure 4) • Use short skirts (if no waves), shorts boom lengths and sufficient overlap
	Collection areas available on both sides	• Chevron Boom (Figures 6-7) • Open for vessel traffic • Closed if no traffic
	Block for low volume flow	• Sealing • Fill • Dams • Weirs
	Vessels not available	▪ Boom Vane or Flow Diverters (Figure 9)
	Design for volume	▪ Overflow/Underflow dams (Figures 12-13)
	Isolated Areas	▪ Sorbents and Pom-Poms

SAFETY

Oil spill response is an inherently hazardous operation. It involves handling a hazardous material in a marine environment often under less than ideal sea and weather conditions. Deploying, operating and retrieving heavy and cumbersome oil spill response equipment routinely requires physical exertion and subjects responders to heat and cold stress. Responding to spills in fast water environments imposes additional hazards due to the extreme loads placed on equipment and the danger of personnel being swept away in the fast currents. Coast Guard personnel must perform Operational Risk Management (ORM) as outlined in COMDTINST M35003 before initiating response actions. (see process below).

Operational Risk Management Process

1. Identify Mission Tasks
2. Identify Hazards
3. Assess Risks
4. Identify Options Tables
5. Evaluate Risk vs. Gain
6. Execute Decision
7. Monitor Situation

Table 3 summarizes the major hazards, potential injuries and risk control measures associated with fast-water oil spill response. The water hazards are defined in some detail as these are the single most dangerous hazards associated with fast water response.

If an individual should accidentally fall in the water, there are a number of things that both the victim and rescuers should remember:

- Don't swim against the current. Swim perpendicular.
- Swim on back, feet downstream.
- Use hands and feet to fend off obstructions.
- Do not tie rope around swimmer or rescuer.
- Angle rescue lines down current.
- Stay on upstream side of the line.
- Never clip into the line.

Table 3. Fast-water oil spill response hazard summary.

Hazard	Injury Potential	Control
Slips, Trips and Falls	Broken limbs, lacerations, head injuries	Awareness, protective clothing, safety lines
Ergonomic	Back injury, joint injuries, hernias	Proper lifting methods, lifting devices
Heat and Cold Stress	Frost bite, hypothermia, heat stroke	Proper clothing, nutrition, rest, & medical monitoring
Flammability – Fire & Explosion	Death, severe burns, broken limbs, loss of eyes	Awareness, proper ventilation, monitoring
Oil Toxicity	Eye/skin irritation, nausea, dizziness, long term effects	Air monitoring, respiratory protection, gloves, coveralls
Line Hazards	Death, loss of limbs & eyes, broken limbs	Adequate line strength, safety observer, knife available
Heavy Equipment Hazards	Damage to eyes, hearing loss, exhaust inhalation, cuts and abrasions	Eye and ear protection, secure loose clothing, stay clear of danger points/ exhaust
Water (drowning)	Critical - death, hypothermia **Consider the following:** • Don't swim against current, swim perpendicular • Swim on back, feet downstream • Use hands and feet to fend off obstructions • Do not tie rope around swimmer or rescuer • Angle rescue lines down current • Stay on upstream side of the line • Never clip into the line	• Buddy System • Life jackets • Cold weather gear • Fall restraints • Life rings, boat hooks • Rescue boats • Avoid waders • Bicycle helmets can be substituted for hardhats only if no overhead hazards exits • Avoid slip on fireman boots • Avoid loose clothing

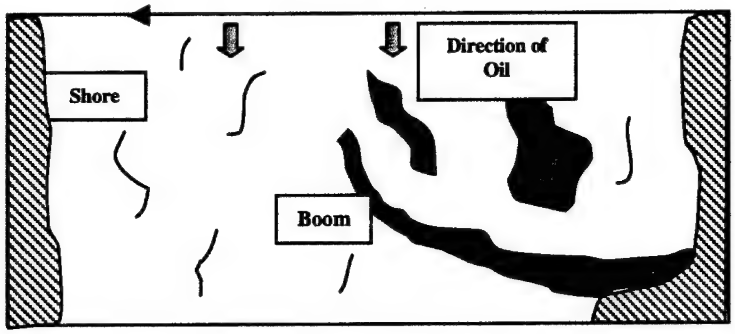


Figure 2. Single diversion boom.

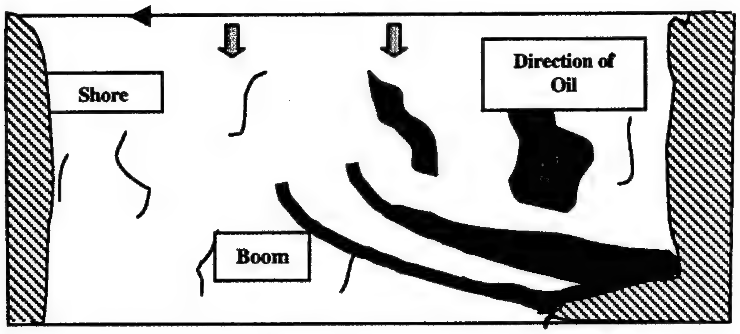


Figure 3. Double boom.

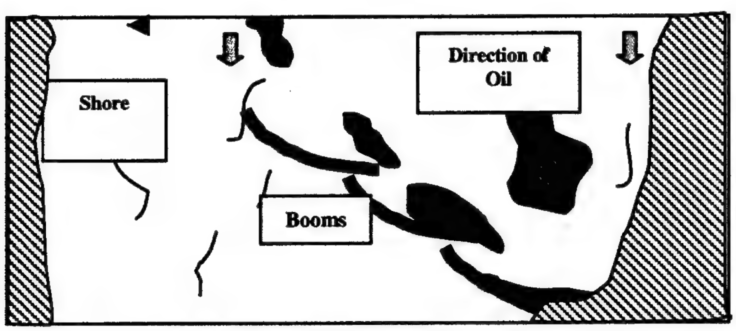


Figure 4. Cascade boom.

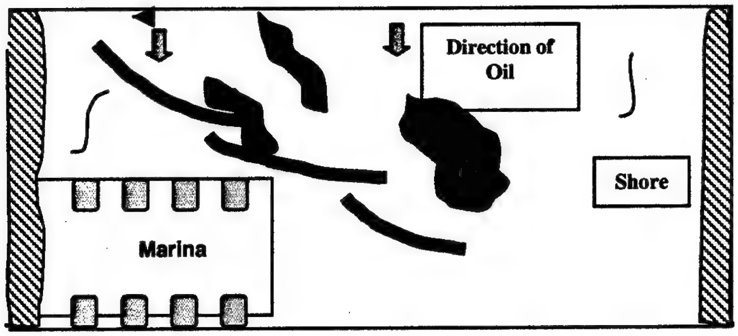


Figure 5. Exclusion boom.

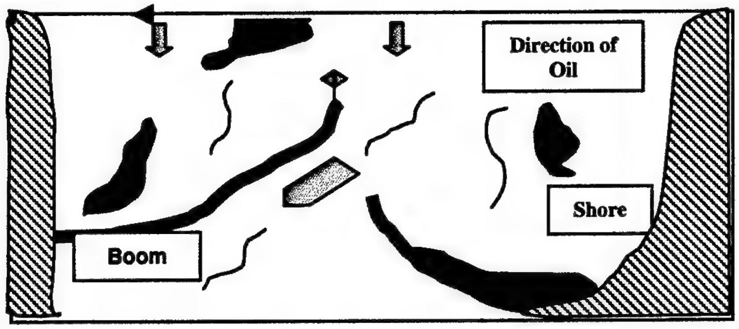


Figure 6. Open chevron boom.

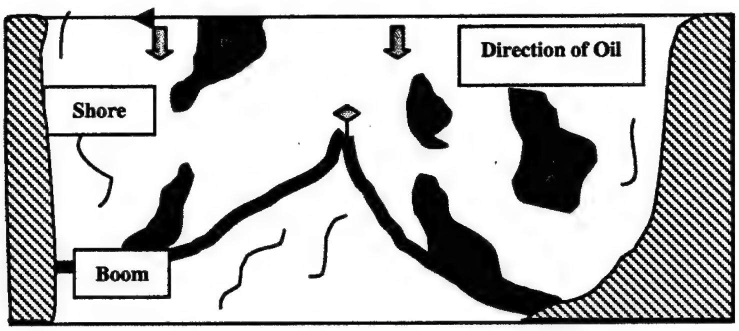


Figure 7. Closed chevron boom.

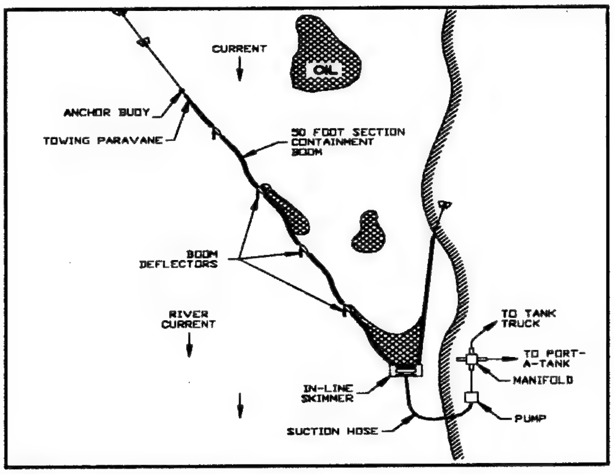


Figure 8. Boom deflectors can be used without multiple anchors.

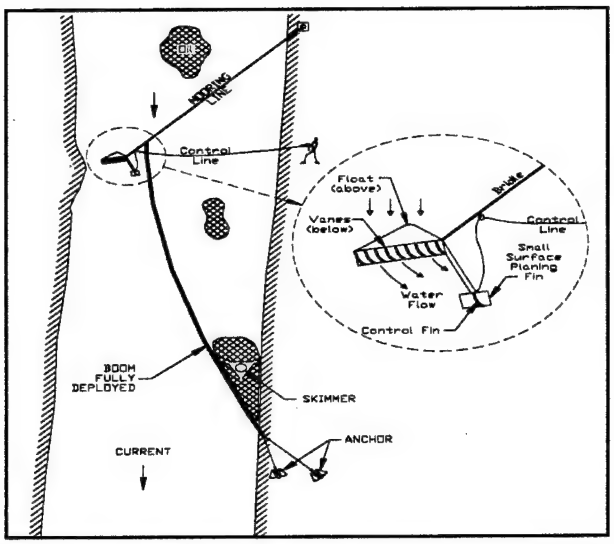


Figure 9. Boom vane deploys and retrieves deflection boom from shore to allow vessel passage.

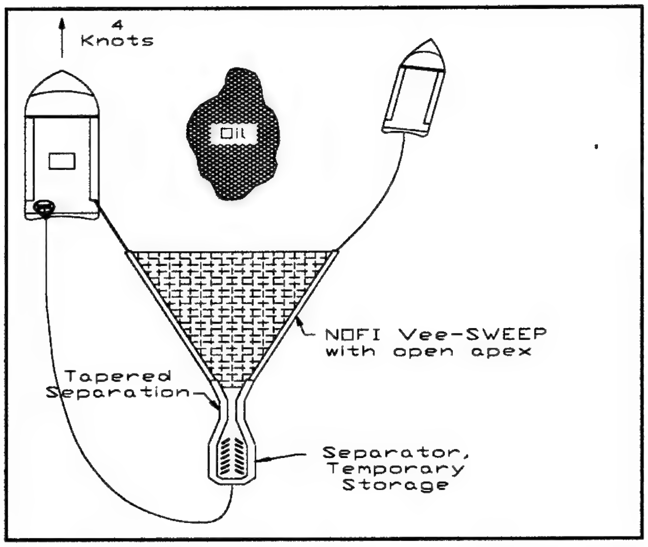


Figure 10. The NOFI Vee Sweep™ with tapered channel separator.

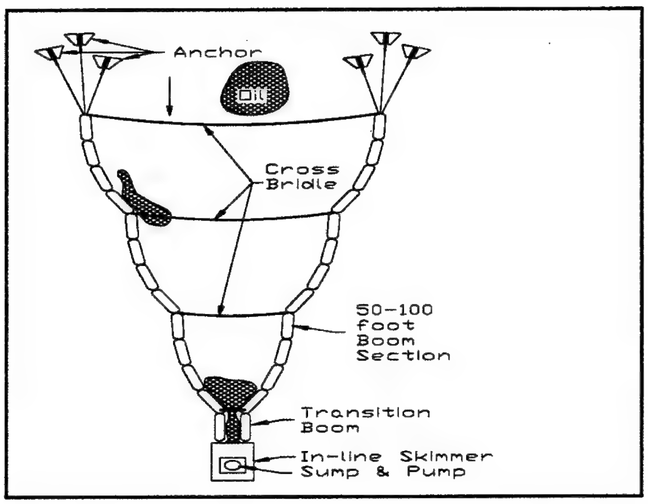


Figure 11. Wide-mouth V-shape boom with attached skimmer.

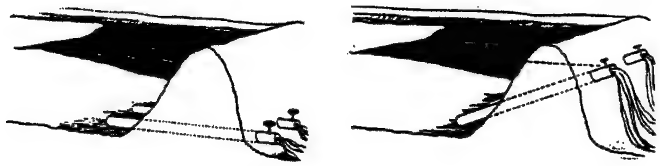


Figure 12. Earth underflow dam.

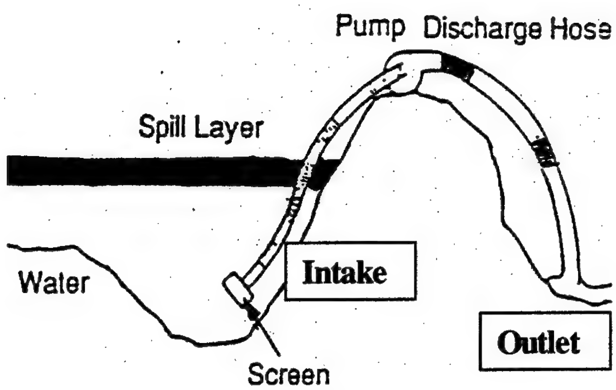


Figure 13. Overflow dam.

HYDRODYNAMIC CONSIDERATIONS AND BOOMING RESOURCES

In assessing the overall feasibility of implementing a fast water booming tactic, it is necessary to determine key hydrodynamic parameters and assess the adequacy of on-scene resources based on these parameters. The definition's process for accomplishing this is depicted in Figure 14, which outlines a procedure for determining the necessary parameters.

Definitions:

- Current Speed (V in knots) and Water Depth (D in feet)
- Profile Length-width that needs to be boomed: This is the value X in the bottom of figure 15.
- Maximum Deployment Angle of the boom (from Figure 15 or Table 4),
- Minimum Length of Boom required (Lboom from Table 4),
- Total Force exerted on the boom (Tboom from Table 4), and
- Number of Anchor Points (AP#) required assuming a minimum of 50 feet of spacing (AP# from Table 4).

Mooring Line:
A conservative estimate of the total length of mooring line (Lline) required per anchor point is D X 7. The tension on each mooring line is estimated by Tline = Tboom / AP#.

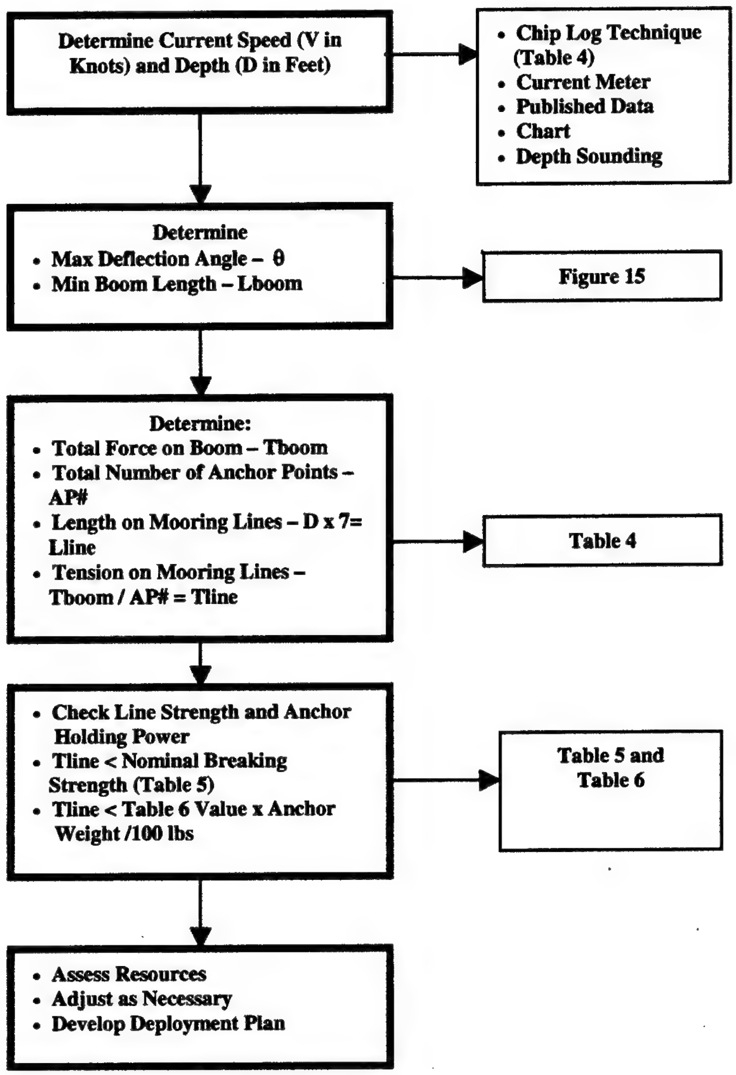
The tension on each mooring line should then be checked against the lines Nominal Breaking Strength (from Table 5) and the Holding Power of each anchor (from Table 6). The value of the Tline should be less than both these values.

Boat Horsepower:
The horsepower required (HPmin) for a deployment vessel to maintain the boom at this deployment angle in the current can be estimated as follows:

- For an outboard motor: HPmin = Tboom/15
- For an inboard motor: HPmin = Tboom/20
- For a jet drive motor: HPmin = Tboom/10

Anchoring:
Examples of anchoring techniques are shown in Figures 16-18.

Figure 14. Hydrodynamic considerations and booming requirements.



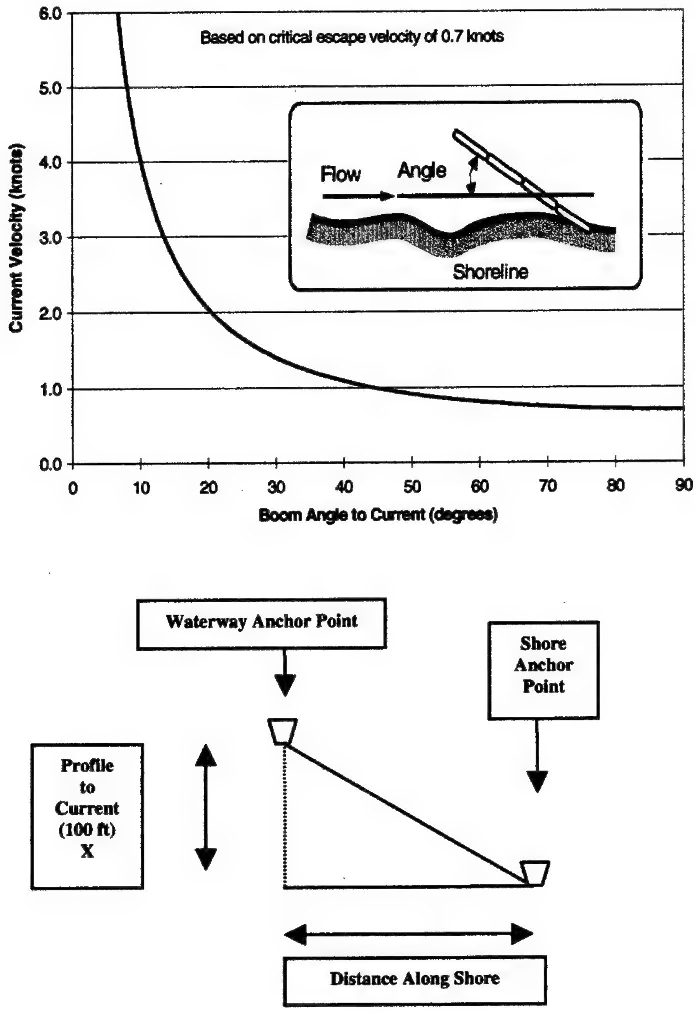


Figure 15. Maximum boom deployment angles required to prevent oil entrainment.

Table 4. Boom Hydrodynamics Table for 100 foot profile. (For larger values of X, values of Lboom, Tboom and AP# can be easily calculated by multiplying by the multiple of 100 feet (X feet/100 feet)).

Time to Drift 100 Feet (Seconds)	Velocity (Knots)	Max Boom Deflection Angle (Degrees)	Boom Length Required for 100 ft. Profile to Current (feet)	T=Total Force on Boom (pounds) (without Waves) K=2 per 100 ft. of boom length			Total Force on Boom (pounds) (with Waves) K=4 per 100 ft. of boom length			Anchors if Placed every 50 ft. or less
				6 inch boom draft	12 inch boom draft	18 inch boom draft	6 inch boom draft	12 inch boom draft	18 inch boom draft	
100	0.5	90	100	25	50	75	50	100	150	3
60	1.0	45	150	71	141	212	142	282	424	4
40	1.5	30	225	112	225	338	224	450	676	6
30	2.0	20	300	137	274	410	274	548	820	7
20	3.0	13	450	202	405	607	404	810	1214	10
15	4.0	10	625	284	567	851	568	1134	1702	14
12	5.0	8	725	348	696	1004	696	1392	2008	16
10	6.0	7	875	438	877	1316	876	1574	2632	18

Equations for Boom Force (Tboom) in Table 4

For a quick approximate load on a boom that is anchored at an angle of between 10 and 30 degrees to the current, use the following formula:

$T = K * A * V^2$ where:
T = tensile force, lb_f
K = constant, $lb_f/(ft^2 \times knots^2)$
A = projected area of the submerged portion of the boom, ft^2
V = tow speed, knots

The projected area of the boom was calculated based on the boom draft, and the length of the boom normal to the water current (i.e., the direction of travel):

$A = d * L * \sin\theta$ where:
A = projected area of the submerged portion of the boom, ft^2
d = boom draft, feet
L = boom length, feet (100 ft)
θ = diversion angle (10°, 20°, 30°)

Table 5. Nominal line breaking strengths (pounds).

Diameter (inches)	Manila	Polypropylene (Three-Strand)	Nylon (Triple Strand)	Nylon (Double Braid)	Polyester (Double Braid)
5/16	900	1700	2300	3400	2400
1/2	2380	3800	5600	8500	5750
5/8	3960	5600	8910	15200	9000
1	9000	13000	23000	26500	26800
2	22500	32000	60000	74000	69900

Table 6. Anchor holding power as a multiple of dry weight for 100 pounds.

Anchor Type	Soft Soils	Hard Soils
Danforth/LWT	12.6	31.6
STATO/NAVMOOR	27.7	25-33
Navy Stockless	3.5	11

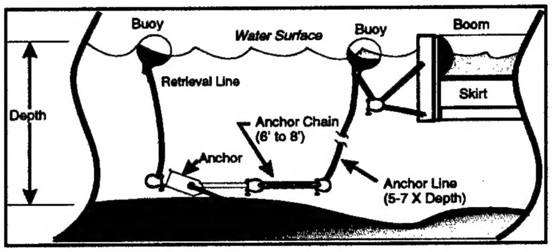


Figure 16. Typical boom mooring configuration.

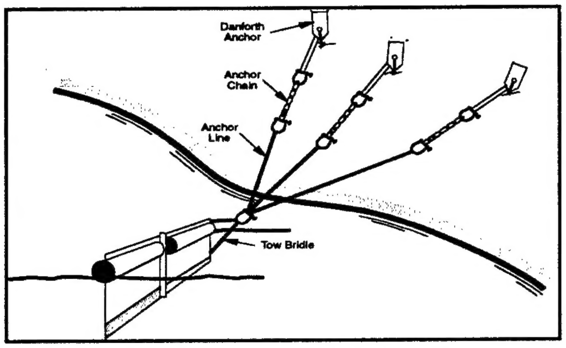


Figure 17. Mooring boom with multiple anchors.

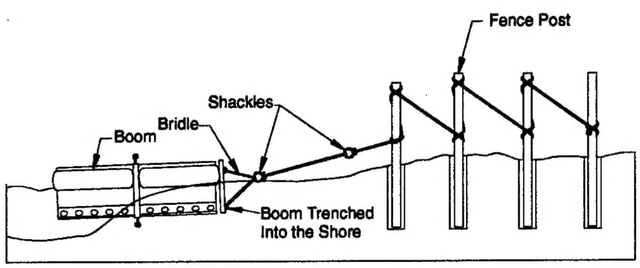


Figure 18. Typical shoreline boom mooring system using posts.

Table 7. Fast water worksheet.

FAST WATER WORK-SHEET	1.Incident Name:	2.Date/time prepared:	3.Operational Period	4.Attachments
5. Fast Water Type	Rivers/Canals (non-tidal) ☐ Rivers/Canals (tidal) ☐ Small Streams/Culverts/Creeks ☐ Coastal areas ☐ Harbors/Bays ☐ Breakwaters and Harbor entrances ☐ Other (specify):			

	Oil Type	Oil Amount	Temperature °F	Humidity %	Evaporation in 24 hours %	Wind (mph)	Visibility (Ft)	Rain, Sleet, Snow	Water (°F) Temperature	Other
6. Background Info										

7. Safety Hazards	Confined Space ☐ Noise ☐ Heat Stress ☐ Cold Stress ☐ Electrical ☐ Animal/Plant/Insect ☐ Ergonomic ☐ Ionizing Rad ☐ Slips/Trips/Falls ☐ Struck by ☐ Water ☐ Violence ☐ Excavation ☐ Biomedical waste and/or needles ☐ Fatigue ☐ Other (specify)
8. Personal Protection	Life Jackets ☐ Oil resistant gloves ☐ Shoulder length resistant gloves ☐ Level D ☐ Eye protection ☐ Cold WX Gear ☐ Level C ☐ Splash Suits ☐ Hearing protection ☐ Fall protection ☐ Water ☐ Sun screen ☐ Wet Suits ☐ Dry Suits ☐ Portable first aid kits ☐ Other (specify)

9. Potential Booming Locations	ETA Oil Impact	Natural Collection Point	Shoreline wave energy	Current Speed & Direction	Access	Water Depth	Tidal Influence	Bottom Amenable to Anchors	Debris, Ice	Shore Sensitivity	Historical Economic Concern	Nav Traffic	Strategy Selec-tion
		Yes ☐ No ☐	High ☐ Med ☐ Low ☐		Land ☐ Water ☐ Air ☐		High ☐ Med ☐ Low ☐	Yes ☐ No ☐	High ☐ Med ☐ Low ☐	High ☐ Med ☐ Low ☐	High ☐ Med ☐ Low ☐	High ☐ Med ☐ Low ☐	
		Yes ☐ No ☐	High ☐ Med ☐ Low ☐		Land ☐ Water ☐ Air ☐		High ☐ Med ☐ Low ☐	Yes ☐ No ☐	High ☐ Med ☐ Low ☐	High ☐ Med ☐ Low ☐	High ☐ Med ☐ Low ☐	High ☐ Med ☐ Low ☐	

10. Selection Strategies	Current < 2 Knots	Current > 2 Knots	Room to Maneuver	Collection Possible on Opposite Sides
Rivers/Canals (non-tidal)	Single Diversion Booming (Skirt < 12 inches) (SDB < 12) Sorbents (isolated areas) (SRB) Exclusion Booming (EXB) Encircle Booming (ECB)	Single Diversion Booming (Skirt < 6 inches) (SDB < 6) Cascade Booming (CSC)	Skimmers (SK)	Chevron Booming (CHV)
Rivers/Canals (tidal)	Double SDB < 12, ECB, SRB	Double SDB < 6, CSC	SK	CHV
Small Streams/ Creeks/Culverts	Fill, Dams, Weirs Underflow/Overflow Dams (UFD/OFD) SRB		SK (small)	
Coastal Areas	ENC, SDB < 12 (no waves), SRB	CSC	SK	
Harbor/Bays	SDB < 12, ECB, SRB	SDB < 6, CSC	SK	CHV
Breakwaters/ Harbor Entrances	SDB < 12, ECB, SRB, Fill, Dams, Weirs, UFD, OFD	SDB < 6, CSC	SK	CHV
Prepared by:		Page ________ of __________.		

Table 8. Conversion tables.

CONVERSIONS AND EQUIVALENTS

AREA (s=statute, n=nautical)		
Multiply	**by**	**to derive**
meters^2	**10.76**	**feet^2**
feet^2	**0.0929**	**meters^2**
kilometers^2	**0.386**	**s. miles^2**
s. miles^2	**2.59**	**kilometers^2**
s. miles^2	**0.7548**	**n. miles^2**
n. miles^2	**1.325**	**s. miles^2**
kilometers^2	**0.2916**	**n. miles^2**
n. miles^2	**3.430**	**kilometers^2**

VOLUME		
multiply	**by**	**to derive**
barrels	**42**	**gallons**
barrels	**5.615**	**feet^3**
barrels	**158.9**	**liters**
barrels	**0.1589**	**meters^3**
feet^3	**7.481**	**gallons**
gallons	**3.785**	**liters**

WEIGHT		
multiply	**by**	**to derive**
kilograms	**2.205**	**pounds**
metric tons	**0.984**	**long tons**
metric tons	**1,000**	**kilograms**
metric tons	**2,205**	**pounds**
long tons	**1,016**	**kilograms**
long tons	**2240**	**pounds**
short tons	**907.2**	**kilograms**
short tons	**2,000**	**pounds**

TEMPERATURE	
Calculate	**To derive**
5/9(°F-32°)	**°C**
9/5°C+32°	**°F**

DENSITY ESTIMATIONS			
	Barrels/Long Ton		**Notes:**
	Range	**Average**	• 1 Long Ton equals 2,200 lbs. • As a general approximation, use 7 bbl. (300 U.S. gallons) per metric ton of oil. • 6.4 barrels/long ton is neutrally buoyant in fresh water. Open ocean neutral buoyancy values are generally in the 6.21-6.25 barrels/long ton range.
Crude Oils	**6.7 - 8.1**	**7.4**	
Aviation Gasolines	**8.3 - 9.2**	**8.8**	
Motor Gasolines	**8.2 - 9.1**	**8.7**	
Kerosenes	**7.7 - 8.3**	**8.0**	
Gas Oils	**7.2 - 7.9**	**7.6**	
Diesel Oils	**7.0 - 7.9**	**7.5**	
Lubricating Oils	**6.8 - 7.6**	**7.2**	
Fuel Oils	**6.6 - 7.0**	**6.8**	
Asphaltic Bitumens	**5.9 - 6.5**	**6.2**	
Specific Gravity of 1 or an API of 10 equals the density of fresh water.			

Specific Gravity < 1 or an API > 10 indicates product is lighter than fresh water. API Gravity = (141.5/Specific Gravity) – 131.5		
Weight of Fresh Water: pounds/gallon	8.3	Note: Exact weight depends on temperature and salinity.
Weight of Sea Water: pounds/gallon	8.5	

OIL THICKNESS ESTIMATIONS

Standard Term	Approx. Film Thickness		Approx. Quantity of Oil in Film	
	Inches	Mm		
Barely Visible	0.0000015	0.00004	25 gals/mile^2	44 liters/km^2
Silvery	0.000003	0.00008	50 gals/mile^2	88 liters/km^2
Slight Color	0.000006	0.00015	100 gals/mile^2	176 liters/km^2
Bright Color	0.000012	0.0003	200 gals/mile^2	351 liters/km^2
Dull	0.00004	0.001	666 gals/mile^2	1,168 liters/km^2
Dark	0.00008	0.002	1,332 gals/mile^2	2,237 liters/km^2

Thickness of light oils: 0.0010 inches to 0.00010 inches.
Thickness of heavy oils: 0.10 inches to 0.010 inches.

COMMONLY-USED EQUATIONS

Circle: Area = 3.14 x radius^2 Circumference = 3.14 x diameter	Cylinder/Pipe/Tank Volume = 3.14 x radius^2 x length
	Rectangle/Square Area = length x width
Sphere/Tank Area = 4 x 3.14 x radius^2 Volume = 1.33 x 3.14 x radius^3	Cube/Block/Tank Volume = length x width x height